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ELIMINATION OF DRILL BREAKING ISSUE DURING OIL HOLE DRILL IN VOLVO CRANK SHAFT

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ABSTRACT

During the manufacture of crankshaft for Volvo heavy vehicles, oil holes drill is essential for lubrication purpose. Drill bits are used for the above drilling purpose. The drill bits break due to abnormalities such as coolant pressure, drill cutting edge blunt, rigidity etc. To eliminate this breakage issue, some of the essential parameters such as point angle, honing angle, lip height etc. of drill nomenclature as well another factor like coolant, speed, machine malfunction etc. are modified. This project deals with breakage analysis of existing drill bit due to vertical machine parameters and constituent conditions of the machine during drilling.

KEYWORDS: Burr, Coolant, Pilot Drill & PM Analysis

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Original Article

INTRODUCTION

The breakage of 4mm drill bit is a very frequent problem associated in VMC during oil hole drill of crankshaft for lubrication system as the 4 mm drill bit is very sensitive. Breakage occurs due to some abnormalities which were addressed in this work. With the help of PM analysis and through the study of all the parameters associated with the breakage, this work also aims to minimize the breaking issue. This work also deals with the removal of these abnormalities such as the burr, coolant pressure, feed rate etc. The sequence of the operations in VMC for crankshaft has been listed below

- Center Drill on Both Ends
- Long End & Journal Turning
- Shorten and Journal Turning
- Pin Turning
- Oil Hole Drill
- Face hole Drilling

Bhargab Kalita et al [1] reviewed the experimental investigation and optimization of process parameters in drilling mild steel with HSS drill bit using Taguchi Method Methodology to obtain minimum surface roughness. It has been observed that the minimum surface roughness of a machined workpiece is influenced by several process

parameters such as spindle speed, feed rate, cutting fluid, drill tool diameter etc.

L. Francis Xavier et al [2] studied the influence of effective parameters for improving deep hole drilling process by the conventional method. In this study, a review of the literature on the conventional deep hole drilling process to produce small deep holes was con-ducted. They found out that deep hole drilling process encounters various threats like tool wear, friction, Built up Edge and tool deflection depending upon the material being machined. Various factors like tools torsional rigidity, tool geometry, cutting edge preparation, tool coating, coolant supply and proper chip disposal are to be considered for the effective deep hole drilling process.

Bajirao H. et al [3] designed and developed a gearbox for Multi-Spindle Drilling Machine (SPM) and this project emphasis on designing, modeling (AutoCAD) and developing of gearbox which operate the multi-spindle drilling machine for drilling operation of counter bore of 5 mm, 6.8 mm and 14.4 mm for a cylinder block. These results prove that the special purpose machine which is introduced, plays a vital role in the heavier production, and which to be achieved by developing gearbox which operates to different types maximum numbers of drilling tools at a time.

M. Ibrahim Sadik et al [5] applied different cooling strategies in the drilling of metal matrix composite as the conventional cutting fluids are known for being expensive, polluting and a non-sustainable part of modern manufacturing processes. The current study intends to cover the indexable insert drilling of aluminium--silicon carbide (Al-SiC) metal matrix composite (MMC) using different diamond coated carbide inserts. Response Surface Methodology (RSM) and SEM analysis were incorporated to evaluate the tool performance and to understand the wear development in the drilling of MMC. The results revealed an advantage in the favor of CO2 cooling concerning tool life, precision and surface finish. Drilling with an internal supply of CO2 significantly improves the tool life. The internal supply of CO2 generated the best precision and surface finish compared to the other cooling strategies. By studying these parameters we can able to find the root causes of the problem and the corresponding solution by eliminating the causes.

Based on the above literature survey, this work dealt with the study of drill breakage for 2 months in VMC 1 and VMC 2 with day by day analysis of causes and to solution by which it is solved. There is two type of problems associated with the breakage issue: some issues like the failure of machine part are solved instantly and some problem like bur interruption takes long time solution. This work focuses mostly on the fixed or long time problem.

METHODOLOGY

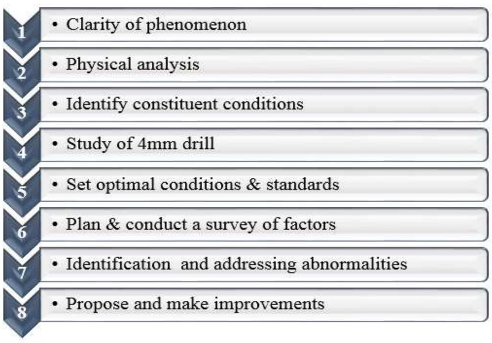


Figure 1: Steps in Methodology

The steps followed in the breakage study were illustrated in Figure 1. The study of drill breakage was done with the 5W 1H method. This method has shown a clear view of the problem identification and the way of solution for the

problem identified. This method helps us to find the phenomenon in the breaking of 4mm drill bit such as when it gets breakdown; how many number of holes the drill bit gets the break and from which portion it gets break and in which machine the maximum number of break down is happening.

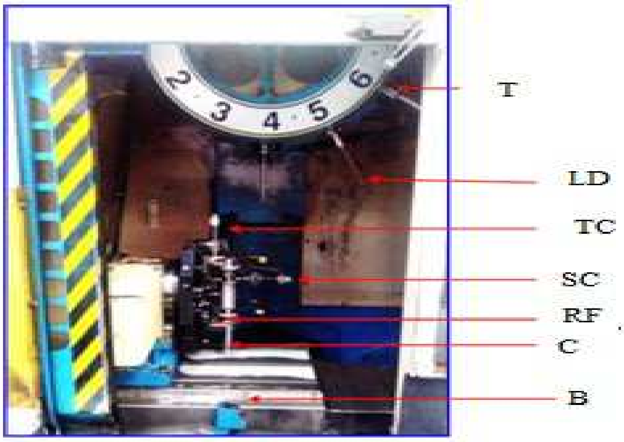


Figure 2: Vertical Milling Machine
T=Tool Magazine,
LD=4mm Long Drill,
TC=Top Clamp,
SC=Side Clamp,
RF=Rotary Fixture,
C=Component, B=Bed

All the components of VMC as shown in Figure 2 such as tool holder, work table, tools, rotating mechanism of the tool holder, cooling system etc. has been studied through the visual inspection. Performance parameters such as the working condition of the tool holder, heat transfer rate by coolant, the feed rate of the system of the work table run etc. The physical analysis leads to the problem identification and its rectification.

DRILL BREAKAGE DETAIL

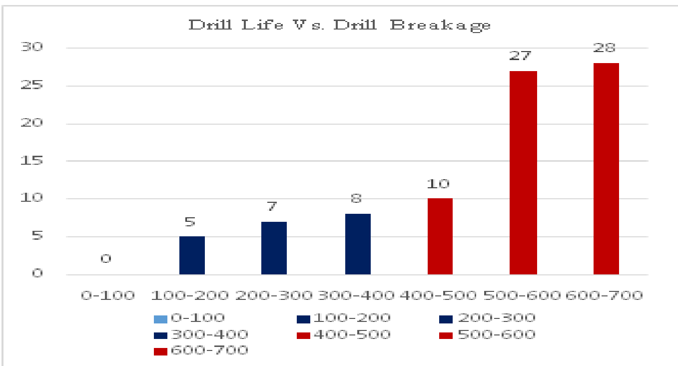


Figure 3: Drill life Vs. Drill Breakage

The graphs shown above depict the phenomenon of drill breaking with respect to tool life. The tool life decreases with increase in drill breakage as shown in Figure 3. It means that the maximum drill breakage occurs during the period of 60 to 90% of their tool life.

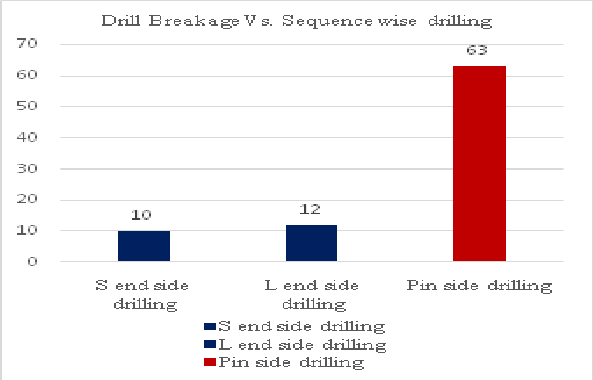


Figure 4: Drill Breakage Vs Drilling Sequence

There is three sequence of drilling takes place in drilling of crankshaft: (1) Short end side drilling; (2) Long end side drilling; (3) Pin side drilling. Fig. 4 shows that the drill breakage is maxi-mum at pin side drilling of Volvo crankshaft. It was observed that the major causes of drill breaking were

- End mill related
- Pilot drill related
- Man related
- Tool related
- Machine Malfunction

PM Analysis

The above issues can be analyzed through a quality method call PM analysis. The consequences, rectifications etc. for the above issues are depicted in PM analysis chart which is shown in Table 1.

Table 1: PM Analysis Chart

Volvo-636 Crankshaft				
Phenomena : In Volvo-636 Crankshaft diameter 4 mm oil hole drilling operation, Drill got broken due to excess Load both part & drill got rejected (Rejection PPM is 2314 PPM)				
Check Part	**Check Item**	**Std. Value**	**Measured Value**	**Decision**
Process Parameters	Pin Clamping	40-50	44	ok
	Coolant	6-8	8	ok
	Coolant pressure	80±5	71	Not ok
Machine	Coolant condition	No Hydraulic oil mix up with coolant	Hydraulic oil mix up with coolant	Not ok
	Through Coolant condition	No burr entry in Through coolant	Burr entry in coolant tank	Not ok

The PM analysis chart shown below in Table 2, helps to identify the constituent conditions responsible for the drill breakage and some of the factors responsible for the drill breakage are shown below:

- Coolant conditions
- Hydraulic Oil Leak
- Bur problem

Table 2: PM Analysis Chart

Volvo-636 Crankshaft			
Phenomena : In Volvo-636 Crankshaft diameter 4 mm oil hole drilling operation, Drill got broken due to excess Load both part & drill got rejected (Rejection PPM is 2314 PPM)			
Check Part	**Check Item**	**Trouble Shooting Method**	**Result**
Process Parameters	Pin Clamping	NIL	
	Coolant	NIL	
	Coolant pressure	Correct the coolant pressure	A
Machine	Coolant condition	Hydraulic hose change frequency & Rotary table seal change	B
	Through Coolant condition	Over flow Passage to be closed to avoid Burr entry	C

The abnormalities identified above are mostly associated with the coolant circuit of VMC and they need to be addressed in order to find out the problems associated with the breakage.

VMC COOLANT CIRCUIT

At present, an internal coolant circuit is fitted at the center position of VMC along with a filtration tank as shown in Figure 5.

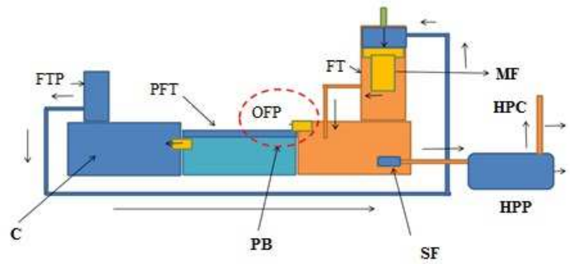


Figure 5: Coolant Circuit of Vertical Milling Machine

FTP=Filtration Tank Pump

C=Coolant for Filtration Tank

PFT=Preparted Filtration Tank

OFP=Over Flow Passage

FT=Filtration Tank (25micron)

SF=High pressure suction Filter

PB=Possibility of the Burr

HPP=High pressure Pump

HPC=High Pressure Coolant
MF=Micron Filter (25 microns)

Overflow passage is indicated with a red dotted line in the above Figure 5. In order to prevent the mixing of coolant and bur, coolant is stored separately in coolant tank and it passes through a filtration tank where the impurities and the coolant are separated. Even though, burr and coolant are separated through filtration tank some problems (addressed below) need to be rectified.

Coolant Pressure Restoration

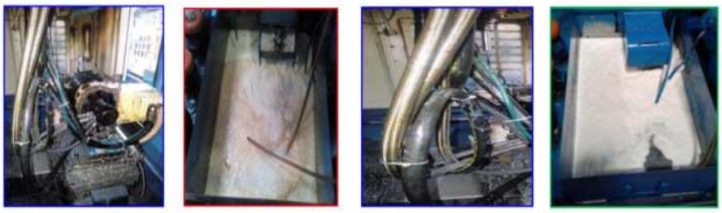
Variation in the coolant pressure is the major cause for the drill breakage. Pressure reducing valve and Pressure gauge are the two components involved in pressure regulation of the coolant. If any -one of these components is malfunctioning, the low-pressure cool-ant can't remove all burs and as a resulting tool gets broke. Figure 6 (a) and (b) shows the pressure gauge and pressure reducing valve used for coolant pressure restoration. This reveals that these two components should be maintained at regular intervals. Figure 6 (c) and (d) represents the difference between the coolant pressures.

(a) (b) (c) (d)

Figure 6: Coolant Pressure Restoration

Hydraulic Oil Leak

Hydraulic oil is responsible for the lubrication of VMC and it is supplied through a hose which fixed to the rotary table as shown in Figure 7 (a). Due to the extended use of hydraulic hose, the hydraulic oil gets to mix with coolant as shown in Figure 7 (b) which makes the concentration of hydraulic oil gets decrease and the table will not work properly as a result run out is happened so tool gets the break. It is mandatory to increase the hose life and hose should be changed frequently after a fixed time. Figure 7 (c) & (d) shows the replaced hose and pure coolant flow without mixing of hydraulic oil.



(a) (b) (c) (d)

Figure 7: Hydraulic Oil Leak

Burr Entrapped in through Coolant Tank

In case of overflow of bur during drilling, the bur can entrap in coolant tank as shown in Figure 8. If the bur present in the coolant is not filtered, it may block the coolant passage, prevents the coolant flow. Due to improper cooling, a tool can break because of running out. It is necessary to prevent the flow of burr in the coolant.

(a) **(b)**

Figure 8: Mixing of Burr with Coolant

Chips in through Coolant

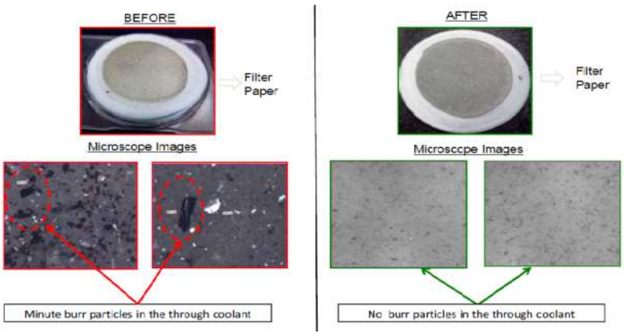


Figure 9: Chips in the Coolant

The microscopic images of the coolant with bur (before and after filtration) are shown in Figure 9. The images shown below depicts that the quality of filtration depends on weight and impact of burr on the filter paper. The orientation of burr may not be same all the time as a result filter paper gets damage and there is a possibility for the burr to get mixed with coolant. This problem can be eliminated after the implementation of magnetic filtration system because the magnet is not affected by the orientation or sharpness of the burr.

IMPROVEMENT IN THE SYSTEM TO ERADICATE THE ABNORMALITIES (ADDRESSED ABOVE)

External Cooling

The amount of coolant supplied through the internal cooling system is not sufficient to remove bur from the pre-drill hole, for workpiece, tool, and work table. Due to insufficient supply, there may be run out in work table which may lead to drill breakage. An external cooling system is suggested in order to eliminate the above problem. The installation of an external cooling system is very simple and it is economically good which is shown in Figure 10. The suggested external cooling system consists of a Coolant reservoir (coolant storage); Pressure regulator (regulates coolant pressure); Coolant nozzle (to focus coolant on tool and workpiece by four parallel directions.

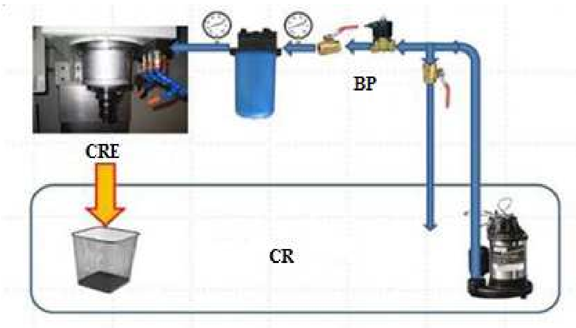


Figure 10: External Cooling
CRE=Coolant Return
BP=By-Pass
CR=Coolant Reservoir

Magnetic Filtration

In order to eradicate the chips in through coolant, a magnetic filtration is proposed as the bur is iron and coolant is non-magnetic. Through the usage of magnetic filtration as shown in Figure 11, the coolant and bur can get filtered efficiently when compared with the filter paper. This system can work as long as possible due to the sustainability of the magnet after many filtrations.

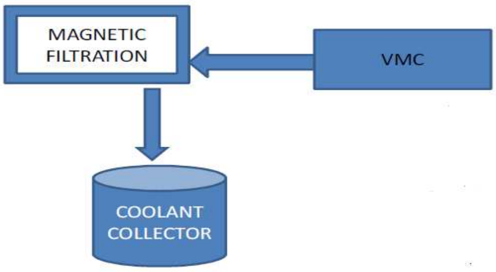


Figure 11: Magnetic Filtration

RESULTS & DISCUSSIONS

Elimination Study

The number of issues related to different sources has been listed in the below table 3.

Table 3: Issues related to VMC1 and VMC 2

Relation	Drill Breakage		
	VMC 1	VMC 2	Total
End mill related	9	4	13
Machine Malfunction	2	13	15
Man related	4	2	6
Pilot drill related	6	2	8
Tool related	6	4	10
Total	**27**	**25**	**52**

Among the issues addressed above, some of the issues such as Endmill, Machine Malfunction, and Tool related without any modification can be solved. A total number of issues related to these three are 38 (from table 3). Man and pilot drill related issues may not be solved without any modification in the system. A total number of issues related to these two are 14 (from table 3).

The percentage of elimination can be calculated as the ratio of the solved issue to the total issue which is 73%. The above-adopted methods cannot eliminate the breakage issue up to 100% as the breaking issue of 4 mm drill bit is very sensitive. The above work proves that the drill breakage issue can be eliminated up to 75%. The drill breakage cannot be eliminated completely as the drill gets to break off due to insufficient cooling, improper filtration, b-axis backlash, drilling sequence and burr. New methods such as external cooling system, magnetic filtration etc. can be implemented which in turn shorts out an existing problem of the system and the breaking of 4mm drill bit can be reduced significantly

The breakage issues which are eliminated through the above improvements are given below:

- Breaking issue due to coolant is eliminated
- Breaking issue due to bur is eliminated
- Breaking issue due to hydraulic leak is eliminated
- Breaking issue due to coolant filtration is eliminated

Some of the problems related to man and pilot drill may decrease if external coolant system added to VMC. The external cooling system reduces the heat from workpiece, work table as well from the tool.

CONCLUSIONS

The above study reveals that the elimination of drill breakage can be further reduced by rectifying the problems related to an oil leak and b-axis error. Further elimination can be done with the help of the external cooling system, magnetic filtration etc. Through the rectification of the above problems, the breaking issue can be further decreased from 73 to 75%.

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